ASELL for Schools Workshop

Laboratory Learning Activity Manual

Oberon High School

1 June 2017

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ASELL SCHOOLS Advancing Science & Engineering through Laboratory Learning
Australian Council of Deans of Science
ReMSTEP
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DEAKIN UNIVERSITY

ACKNOWLEDGEMENTS

We would like to thank:

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WELCOME

Welcome to an ASELL for Schools Workshop!

ASELL (Advancing Science and Engineering through Laboratory Learning) has developed over the last 10 years. This project developed from its physical chemistry APCELL predecessor and then expanded to incorporate all of chemistry (ACELL). After successful trials of using ASELL principles at workshops in physics and biology, the project has now expanded to include biology and physics, and more recently engineering, hence the name change.

The ASELL project has been designed to help address challenges in student learning which arise in science laboratories. By bringing together diverse expertise and resources, it is possible to develop a collection of experiments, which can facilitate student learning, whilst also taking into account variations in student differences. In 2010, the first national ASELL Science Workshop was held at the University of Adelaide.

This ASELL for Schools workshop is the second Victorian workshop to be run under the Australian Mathematics and Science Partnership Funding Grant, which was awarded to ASELL in 2014. This phase of the project has been initiated by Deakin University in conjunction with the University of Sydney with support from ReMSTEP and the Australian Council of Deans of Science. With the introduction of the new Australian and Victorian Curricula now in place, an opportunity exists to address current school-based experimentation and incorporate science inquiry. ASELL for Schools will provide the following three outcomes:

- A resource, a repository of experiments with all associated documentation necessary to run them, ranging from health and safety notes, necessary equipment and resources, notes for technical staff to the science learning objectives and how the experiment achieves them.
- Authentic professional learning workshops on experimentation in schools.
- An interface and interaction between school and university staff.

Today, you will be participating in laboratory activities and discussion sessions to expand your understanding of issues surrounding learning in the laboratory environment. In particular, it is important to be able to experience the experiments as learners.

In addition to the formal program, please take the opportunity to exchange ideas about science and education and get to know each other, as an additional aim of the ASELL Schools project is to build a community of educators interested in laboratory-based education and other aspects of science education.

We would like to gratefully acknowledge the assistance of teachers, technical staff and others in making this workshop possible. A very big thank you to the team at Oberon High School, for hosting this Workshop. Everyone has put in a lot of hard work to get this workshop set up and running. I want to thank everyone!

If you have any questions about the project, please speak with one of the Victorian ASELL for Schools team, who are present.

Sincerely,

Kieran Lim

Kieran Lim
ASELL for Schools Victorian Leader, on behalf of the ASELL for Schools Team

ASELL FOR SCHOOLS WORKSHOP SCHEDULE

ASELL for Schools Oberon High School Thursday 1 June 2017		
9:00 – 9:15	**Arrival/Registration** ***Venue Room 31***	
9:15 – 9:30	**Welcome and Introduction** with Peta White • Introductions (of ASELL for School team and Students and Teachers) • Outline ASELL for Schools • Outcomes for the day • How to use the booklet ***Venue Room 31***	
9:30 – 9:40	Introduction to Laboratory Learning Activity ***Venue Room 31***	
9:40 – 10:40	***Laboratory learning activity 1 – Composite Materials*** *Peta White and John Long* ***Venue Rooms 29 and 31***	
10:40 – 11:10	**Morning Tea** ***Venue Room 31***	
11:10– 11:30	**Teachers:** Teachers deconstruct LLA #1; Inquiry Scaffolding tool; Analysis of Laboratory Learning Activity with Peta White ***Venue Room 31***	**Students:** Discussion and feedback on Laboratory learning activity Ian Bentley ***Venue Room 29***
11:30– 12: 45		**Students:** Using phones to study motion John Long ***Venue Room 29***
12:45 – 12:55	Introduction to Laboratory Learning Activity John Long and Helen Carson ***Venue 31***	
12:50 – 1:45	**Lunch** ***Venue Room 31***	
1:45 – 2:50	***Laboratory learning activity 2 – Crash Test Dummies*** *John Long and Helen Carson* ***Venue Rooms 29 and 31***	
2:50 – 3:10	Discussion and feedback on Laboratory Learning Activity	
3:10 – 3:25	**Teachers:** Overall debrief and Evaluation for the day with Peta White ***Venue Room 31***	**Students:** Overall debrief and Evaluation for the day with John Long ***Venue Room 29***

LABORATORY SESSION 1
COMPOSITE MATERIALS

Contact: Peta White
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ASELL SCHOOLS Advancing Science & Engineering through Laboratory Learning LABORATORY LEARNING ACTIVITY

Composite materials

Introduction

Today's Laboratory unpacks how composite materials can respond differently to unbalanced forces.

Victorian Curriculum Outcome

Change to an object's motion is caused by unbalanced forces acting on the object; Earth's gravity pulls objects towards the centre of Earth (VCSSU103)

Checkout the racing car and surfboard

Giedo van der Garde driving the Caterham CT03 at Sepang International Circuit.

https://commons.wikimedia.org/wiki/File:Giedo_van_der_Garde_2013_Malaysia_FP1.jpg

A surfer at the Cayucos Pier, Cayucos, California.
Photo: "Mike" Michael L. Baird.

https://commons.wikimedia.org/wiki/File:Surfer_at_the_Cayucos_Pier,_Cayucos,_CA.jpg

What could be the same between the materials used a modern racing car and surfboard?
(Hint: focus on the how each is made (manufactured).)

Composite Materials

A composite material is made from two or more materials, each with different physical or chemical properties. But when combined, the whole composite has properties that are different from the individual materials.

Some composite materials are mixtures, like cements, concrete, imitation granite and cultured marble sinks and countertops, and metal alloys.

Some composite materials have the individual materials in separate and distinct parts.

Scientists and engineers are developing new composite materials because they can be stronger, lighter, or less expensive when compared to traditional materials.

Key ideas

Force – a push or a pull

Compression force – a push that squeezes an object to try to make it smaller or shorter.

Tension force – a pull stretches an object to try to make it bigger or longer.

Aim

The composite materials activity enables you to experience and investigate the way combining the properties of two materials (polystyrene and gaffer tape) can result in a particular type of composite material. The properties of the composite are very different from the properties of the original. In the process, you will learn about tension and compression forces.

Why do we make composite materials?

Consider the similarity between these two pictures

A bacon, lettuce and tomato sandwich on toasted bread.
Photo: Steven Groves from Denver (CO), USA.
http://en.wikipedia.org/wiki/Sandwich#/media/File:BLT_sandwich_on_toast.jpg

Glass Aluminum Reinforced (GLARE) honeycomb composite sandwich structure.
Photo: NASA.
http://ballistics.grc.nasa.gov/Photographic%20Data/Images/glare_honeycomb.jpg

How do you think **sandwich composite materials** are made?

Your challenge

Today you are a scientist who has been paid to design a stronger composite product for as little cost as possible. The following demonstration is to prepare you for the task.

Part 1: Demonstration of the effectiveness of sandwich structures

Things to note from the demonstration:

- A polystyrene plank is not very strong. (Footnote [1])
- When additional materials are layered onto the polystyrene it becomes a composite material and its properties change – it becomes stronger.

[1] Styrofoam is a particular brand name for polystyrene.

Draw and label the equipment and what happened.

Part 2: Comparison of three products: polystyrene on its own and 2 composite materials with different structures

Think about the demonstration you have just seen. Can you think of two different ways of making sandwich composite structures using the materials and equipment available to you?

Re-do the demonstration with your group. You will need to work out a way of measuring the rigidity or how much bending there is for each individual weight added. Talk with your partner to decide how you will measure the amount of bending and how you will record the data in an appropriate table below. Your support structures need to be 21 cm apart (Footnote [2]).

Record the data in an appropriate table to show the difference between the polystyrene and the composite material structures 1 and 2.

[2] 21 cm has been chosen because iot is the width of an A4cpage and is easy to set up. If you wish, you could use some other separation distance.

Graph the data to show the difference between the polystyrene and the composite material structures 1 and 2.
(Hint: put all the data on a single graph.)

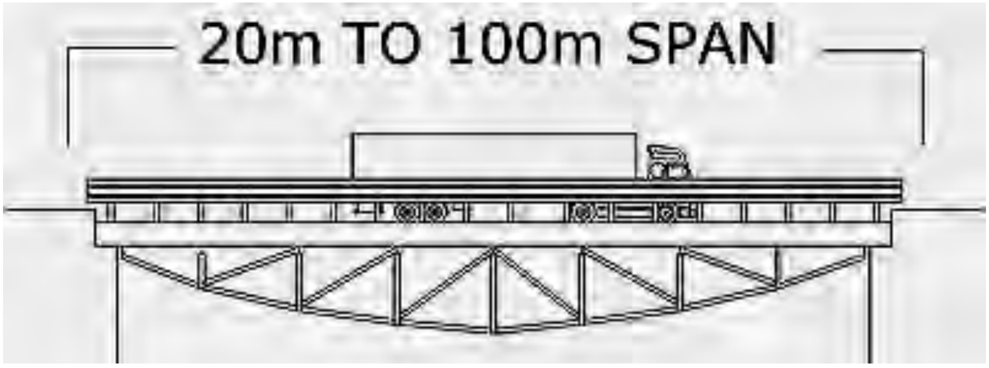
Describe in words what was revealed through the data analysis of the graph.

Part 3: Analysis of forces

Roofs and bridges have to span large gaps while supporting massive weight.

Consider the bridge below. The schematic diagram following is of a similarly designed bridge.

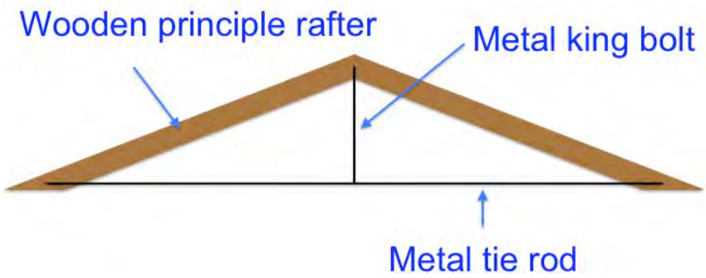
Steel frame truss bridge, located on the Southern Highway, Belize, Central America. Photograph © John Reid & Sons (Strucsteel) Ltd.
http://www.steel-bridges.com/under-truss-bridge.html



Steel frame truss bridge design. The concrete deck and the steel strusses form a composite structure. Diagram © John Reid & Sons (Strucsteel) Ltd.
http://www.steel-bridges.com/under-truss-bridge.html

Consider the roof/ceiling below. The schematic diagram following is of a similarly designed roof.

Composite truss roof, Tahoe Ridge House, California. Photograph © WA Design Inc
http://www.wadesign.com/newbuilding#/tahoe-ridge-house/



Simple composite truss roof

All these roofs and bridges have one element (or part) that spans the top of the structure and one element that spans the bottom of the structure.

Can you represent the main forces that you think are acting on these two elements of the structures?

How many elements span your polystyrene structure? Why do you think the polystyrene structure is relatively weak?

How many elements span your sandwich structure? Can you represent why you think the sandwich structure works to alter the strength and rigidity?

What is the role of the tape and what properties make it work well?

Would one piece of tape above or below the polystyrene be as effective as two pieces of tape in a bridge structure?

Discuss with your team, how a composite material might be used in boat hulls, swimming pools, race car bodies, surf boards, spacecraft and aircraft. Can you represent why you think an "open-sandwich" structure (similar to tape only on one side of the polystyrene) would perform better or worse than a regular sandwich structure (similar to tape on both sides of the polystyrene)?

Part 4: Challenge

Your job as a Scientist is to create a stronger composite material using the least amount of material (polystyrene and tape) to reduce cost.

Work with your group to design to strongest sandwich structure composite material using the least tape. Test each design for strength and rigidity to decide the best design.

Decide how you will collect your data for each trial and produce a report that describes the design that works best. Include evidence (data) and an explanation as to why (using diagrams and words).

LABORATORY LEARNING ACTIVITY 2 – CRASH TEST DUMMIES

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Crash Test Dummies

Introduction

One of the key elements of modern automobile design is crashworthiness, or how likely someone in the car will survive if the car is in a crash. Forty years ago, cars were designed to withstand a crash with as little damage to the car as possible. Now cars are designed that the car takes the damage in an accident, not the driver and passengers.

Students exploring Graham. Photograph © Transport Accident Commission.
http://www.tac.vic.gov.au/about-the-tac/media-room/news-and-events/current-media-releases/introducing-graham

The Transport Accident Commission has collaborated with Royal Melbourne Hospital trauma surgeon, Christian Kenfield, Monash University Accident Research Centre crash investigator, David Logan, and Melbourne sculptor, Patricia Piccinini, to produce 'Graham', an interactive lifelike sculpture demonstrating bodily features that might be present in humans if they had evolved to withstand the forces involved in crashes. Studies have shown that the human body can only cope with impacts at speeds people can reach on their own, unassisted by vehicles.

Holden Astra (May 2017 – onwards) frontal offset test at 64km/h.
Photograph © Australasian New Car Assessment Program (ANCAP).
http://www.ancap.com.au/safety-ratings/holden/astra-25ad9072-b3da-4fb0-863e-37045a3cac7c/4fc8d4/images-and-video

In this activity, you are an automotive test engineer. Your task is to investigate what happens to someone in a car during a crash. You will do this by taking high-speed video footage of different kinds of crashes and examining what happens to the occupant during the crash. You will also take some measurements of how far a driver flies out of the car when it crashes into a barrier at different speeds. You will also investigate the effect that adding a crumple zone on the front of the car has on the motion of the occupant during a crash.

Key ideas

Force – a push or a pull

Newton's First Law – Objects at rest stay at rest. Objects in motion stay in a straight line motion unless subjected to an unbalanced force.

Newton's Second Law – The net force acting on an object is equal to the mass of the object multiplied by its acceleration:
$F=ma$

Newton's Third Law – When one object exerts a force on a second object, the second object exerts an equal and opposite force back on the first object.

Kinetic energy – Energy that an object has by virtue of its motion.

Crumple zones – Parts of a car designed to take the hit so that the occupants are protected. The crumple zone absorbs the kinetic energy instead of the driver.

Materials

- Trolley
- Beanie teddy bear (driver or passenger)
- 2-metre ramp
- Obstacle to crash into.
- Go-Pro camera or a modern I-phone with a high-speed camera.
- Computer with VLC media player (or equivalent) installed
- Cardboard for making a seat and a crumple zone.
- Sheets of photocopy paper
- Sticky tape.
- Blu-tack (or similar)
- Tape measure
- Stopwatch

Part A: Motion of a passenger in a crash

In this experiment, teddy is a passenger at the back of the car and the car crashed into a wall. Ted is not wearing his seatbelt. What happens to Teddy during the crash?

Part A: Procedure

1. Using the supplied cardboard and sticky tape, construct a seat for Ted so that he does not fall off the trolley before the collision.

2. Construct a ramp for the trolley to run down. Use more cardboard to make a smooth transition between the ramp and the floor.

3. Use a motionless obstacle, like a brick, for a crash barrier to stop the trolley.

4. Run Ted and the trolley down the ramp and crash it into the crash barrier.

5. Video-record the collision with a high-speed camera. Place a stopwatch in the view of the camera to monitor time.

6. Perform the crash for three different heights of the ramp, corresponding to three different impact speeds – slow, fast, and fastest.

Part A: Data Analysis

1. Draw a picture of your ramp and crash barrier.

2. Study the video footage in slow speed. For each ramp height, describe below the motion of the trolley and Ted during the collision.

3. From the stopwatch data, determine the average time it takes for the trolley to stop and Ted to stop.

4. Describe how Newton's laws apply in the collision. For one crash, how many collisions are there?

Part B: Motion of a driver in a crash

In this experiment, teddy is the driver at the front of the car and the car crashes into a wall. There is no windscreen and no seat belt. What happens to Ted during the crash?

Part B: Procedure

1. Using the supplied cardboard and sticky tape, construct a seat for Ted so that he does not fall off the trolley before the collision, and the seat is at the same level as the front bulkhead of the trolley.

2. Construct a ramp for the trolley to run down. Use more cardboard to make a smooth transition between the ramp and the floor.

3. Run Ted and the trolley down the ramp and crash it into a motionless obstacle, like a brick.

4. Video-record the collision with a high-speed camera. Place a stopwatch in the view of the camera to monitor time.

5. Perform the crash for three different heights of the ramp, corresponding to three different impact speeds – slow, fast, and fastest.

6. For each ramp height, measure how far Ted flies away from the trolley.

Part B: Data Analysis

1. Study the video footage in slow speed. For each ramp height, describe below the motion of the trolley and Ted during the collision.

2. From the stopwatch data, determine the average time it takes for the trolley to stop and Ted to stop.

3. Describe how Newton's laws apply in the collision.

4. Determine the pattern between ramp height and how far Ted travels from the site of the collision and where he stops.

Part C: Effect of a crumple zone

In this experiment, you will add a crumple zone to the front of the trolley. Does the crumple zone lessen the impact on Ted?

Part C: Procedure

1. Using the supplied materials and sticky tape, construct two different crumple-zone bumpers for the trolley. One is paper, one is cardboard.

2. Repeat the previous two investigations with the different crumple zones.

Part C: Data Analysis

1. Draw a picture of your paper crumple-zone bumper.

2. Draw a picture of your cardboard crumple-zone bumper.

3. Study the video footage and measurements in slow speed. For each ramp height, determine if the crumple zone gave Ted any protection during the crash. Which material made the more effective crumple zone? For instance, when Ted is the passenger, Is there any change to his motion during the collision? When Ted is the driver, does he fly as far during the collision?

Part D: A two-trolley collision

In this experiment, one trolley with Ted1 as passenger collides with the rear of a second stationary trolley with Ted2 as the driver. During the collision, what happens to both Teds?

Part D: Procedure

1. Design and perform an experiment to determine what happens in a rear-end collision. The driver of the front trolley has a seat but his head is free to move. The passenger of the rear trolley is not secured to his seat. Perform the experiment for slow, fast, and faster impact speeds.

Part D: Data Analysis

1. Draw a picture of the design of your rear-end collision.

2. Using a similar analysis to Parts A-C, determine what happens to both Teds.